
RELATED ACTIVITIES

In addition to the Pilot Program for the Application of Climate Forecasts and the Climate Outlook Fora held in Africa, Latin America, the Caribbean, and Southeast Asia, NOAA-OGP was involved in several activities related to the use of climate information during 1997-98, including:

- The ENSO Rapid Response Project (RRP);
- The ENSO Signal Newsletter;
- The California Pilot Project on the Use of Climate Information;
- NOAA-OGP ENSO Web Site;
- Regional Assessments of Climate Variability, Social Vulnerability, and Public Policy Program;
- The Economics and Human Dimensions Program;
- The Pacific ENSO Applications Center (PEAC); and
- Applied Research Centers.

The primary aim of these various activities was similar to that of the Outlook Fora and Pilot Applications Projects: to better understand the capacity of society to utilize climate forecast

information. Some activities encouraged and coordinated the use of climate forecasts, and were initiated as a response to the 1997-98 El Niño event, while others monitored and analyzed the actual and potential use of forecasts in a research mode, and have been ongoing programs for several years. All have the ultimate purpose of aiding the mitigation of socioeconomic impacts associated with climate variability. These activities helped build linkages between research and user communities, consolidate knowledge about the applications of climate forecasts, or serve as an effective means of distributing information, helping to support NOAA-OGP's response to the 1997-98 El Niño event. The RRP, ENSO Signal, the California Pilot Project, the ENSO Web site, and the PEAC acted as a direct response, providing decision makers in the United States government and worldwide with quick access to information as the event unfolded. Following is a summary of each project, along with lessons-learned.

ENSO Rapid Response Project

In order to provide the best available climate information for regions worldwide during 1997-98, NOAA-OGP, in cooperation with IRI, implemented the ENSO Rapid Response Project (RRP). The ENSO RRP serves as an interface between the producers and users of climate information by providing monthly updates and other periodic updates of the ENSO RRP products to officials in the United States and abroad and by eliciting their feedback on the usefulness of these climate products. The ENSO RRP distributes a suite of climate products, including:

- Pacific Ocean sea-surface temperature (SST) observation maps and forecasts, and precipitation and temperature observations for regions worldwide and on multiple timescales from NOAA's Climate Prediction Center;
- Net-assessment seasonal precipitation and temperature forecasts for regions worldwide and a comparison of the 1997-98 El Niño SSTs to other El Niño events from IRI;
- A multivariate ENSO Index comparison of recent El Niño events from NOAA's Climate Diagnostic Center (NOAA-CDC);
- Global seasonal precipitation and temperature forecasts from the Center for Ocean Land Atmosphere Studies (COLA); and
- Interpretative material for these products provided by NOAA-OGP, when necessary.

Initially, NOAA-OGP provided monthly updates of climate information through the ENSO RRP for IRI Core group members, officials at NOAA, the Department of Commerce, and other United States government agencies.³⁵ In April 1998, the IRI took the responsibility of providing climate forecast and observational information to its Core Group members. NOAA-OGP continues to provide United States officials, who are either stationed

abroad or require climate information for regions outside of the United States, with ENSO RRP products.

Through the ENSO RRP, NOAA-OGP responded to several requests for information regarding the 1997-98 El Niño, including:

- Officials from United States Embassies in Indonesia, Singapore, Malaysia, the Philippines, and Brazil requested information regarding fires burning in their respective regions. They requested satellite information to constrain the spatial extent of the fires and climate information to determine when rainfall was likely to return to normal, and therefore provide relief from the impacts of the fires.
- World Bank officials informally requested forecast information for Peru to assist in their decision to issue a \$150 million loan to the Government of Peru for El Niño preparations. This loan was later matched by one of \$150 million from the Inter-American Development Bank.
- Officials at USAID-OFDA requested climate forecast information to assist them in targeting areas for disaster preparedness and response activities during the El Niño event. Since September 1997, the ENSO RRP has provided USAID-OFDA monthly updates of IRI net assessment precipitation forecasts (three-month) for several regions of the world such as Central America and Mexico, South America, Africa, and Asia, as well as percent of normal precipitation forecasts for three-month time intervals covering the same regions. In addition, during a disaster period, the ENSO RRP assists USAID-OFDA in obtaining from the IRI and NOAA-CPC specific regional climate information.

³⁵ The IRI Core Group was a select group of individuals from countries and institutions interested in financial sponsorship and management of the IRI Core that met during 1997-98, with the goal of transitioning the IRI from a unilateral activity to a fully multilateral entity.

- Officials at the United States Initiative on Joint Implementation of the United States Country Studies Program requested ENSO RRP products to be sent to government officials in environmental ministries and national meteorological services.
- In September 1997, officials from the Department of State requested climate

information on the impacts of El Niño in North Korea and central China, because these regions were in the midst of a drought. The IRI provided this information, which indicated that the El Niño event may have amplified pre-existing drought conditions by causing below-normal precipitation.

The ENSO Signal Newsletter

The “ENSO Signal” newsletter is a quarterly publication originally created as an outreach tool during the planning of the November 1995 International Forum on Forecasting El Niño: Launching an International Research Institute. It provided update information on the Forum planning process and featured articles from climate scientists and international experts involved in ENSO Research or the use of forecast information. The Forum was convened in response to a request by various nations and organizations to address how best to apply early-warning forecasting capability that could be used for, and incorporated into decision-making practices. This resulted in an initiative to establish the International Research Institute for Climate Prediction (IRI) for the purpose of El Niño forecasting.

Over the past three years, the IRI has progressed toward fully-operational status, while at the same time, the “ENSO Signal” has evolved into a more substantive product that has captured the attention of a wider and more diverse audience. The focus of

the newsletter has shifted to highlight advances in forecast application activities, new ENSO research techniques or scientific conclusions, and socioeconomic issues affected by ENSO. There are currently eleven issues of the Signal, and the readership includes close to 950 national and international individuals and organizations. It is recognized as an educational and informative tool to university students, private organizations, and other government organizations interested in ENSO research and related issues.

The ENSO Signal contributed to OGP’s response during the 1997-98 El Niño in several important ways. It served as a medium for worldwide organizations to highlight updates on their preparations and response to the event; provided Web site addresses to readers who wished to access up-to-date information on the unfolding El Niño; and provided summaries of Climate Outlook Fora in several countries which assessed implications for specific sector-planning activities (water management, food security, etc.) affected by the El Niño event.

Beginning in late Spring 1997, Californians were warned that a strong El Niño was underway, and many in the state began to take measures to prepare for El Niño-driven storms that cause severe flooding, landslides, hill slides, and mud flows. In the midst of these activities, NOAA-OGP in collaboration with the University of California, Santa Barbara (and other state and federal contributors) proposed to conduct a small-scale research pilot project on the use of El Niño-related climate information, and invited decision makers from several climate-sensitive sectors in California to participate. The project began in December 1997, and will continue through the duration of the 1998-99 La Niña event. It includes approximately 25 decision makers and several climate scientists from government and university based institutions.

The goal of the California Pilot Project has been to learn if and how decision makers in climate sensitive sectors can use climate information in order to better prepare for and respond to the impacts of climate variability. Working to achieve this goal, NOAA-OGP provided climate forecasts and observational data on the impacts of this El Niño in easily understandable language. This allowed decision makers to determine if and how climate information could be incorporated into their emergency and regular operations. In addition, NOAA-OGP received detailed feedback on the value of this information from the decision makers.

The primary source of the climate information was NOAA's Climate Prediction Center (NOAA-CPC), whose scientists provided 6-10 day, monthly, and seasonal precipitation and temperature forecasts, a Threats Assessment for the U.S., as well as observational information such as soil moisture indices. International Research Institute for Climate Prediction (IRI) net assessment seasonal precipitation and temperature forecasts for North America were also included. The IRI forecasts, which were less detailed and presented in a format different than those of NOAA-CPC, were included to determine what types of information were best suited to user needs. The United States Geological Survey (USGS), with NOAA's Climate Diagnostics Center

(CDC) and Scripps Institution of Oceanography, provided an experimental streamflow forecast for the Merced River. NOAA-OGP provided interpretive information for these climate products when necessary. Based in part on the results of this research project, NOAA hopes to lay the groundwork for participants and other domestic users to regularly receive and incorporate climate information into their decision making.

Methodology

To identify participants of the pilot project, NOAA-OGP concentrated on attracting a small but diverse group from climate-sensitive sectors such as agriculture, water management, ranching, forestry, health, port authorities, energy, banking, tourism, emergency services, communications, transportation, and local and state planning agencies. NOAA-OGP identified potential participants by directly contacting state agencies as well as by contacting individuals who were quoted in the news media. Originally, about 30 individuals were identified, and about 20-25 of these have been consistent participants in the pilot project.

The methodology used for this pilot project was developed using several sources. Through the experience of NOAA-OGP's Regional Assessments Program (see Regional Assessments of Climate Variability section) the California Pilot Project was able to draw on the experience of other groups who have been working with decision makers to use climate forecast and observational information. In addition, it was necessary to use the expertise of participants of the pilot project in developing the methodology. Therefore, an initial meeting of participants (decision makers, climate scientists, and NOAA-OGP staff) was held in December 1997. This meeting provided participants with an opportunity to discuss how climate can impact their respective sectors, and to agree on how the pilot project would be conducted.

At the December 1997 meeting, it was agreed that NOAA-OGP would send decision makers in California a monthly packet of climate forecast and observational information. This information was

provided by NOAA-CPC and the IRI and later included information from the USGS with NOAA-CDC and Scripps. NOAA-OGP staff produced interpretive information to accompany the graphics so that decision makers could more quickly understand and identify the types of information that most suited their needs. Through the course of the pilot project, the information became more user friendly as comments from decision makers were communicated to the producers of the climate forecasts and incorporated into the production of the packets. In addition, NOAA-CPC maintained a Weekly Threats Assessment Web site at which decision makers, both those participating in the pilot project and others working closely with NOAA-CPC, could access updated information that was sent to them in the packets, and this Web site was updated on a weekly basis.

Another important part of the methodology was to obtain feedback from decision makers on the climate information that they were receiving from NOAA-OGP and other sources (e.g., private sector climate services, local news media). The type of feedback requested from decision makers included documentation and verbal reports for questions such as the following:

- Did you use it to prepare for and/or respond to the impacts of the 1997-98 El Niño?
- How did you use the climate information?
- Was the information useful?
- Can you incorporate climate information into your decision-making process?
- Did you change your institution's operations based on the climate information you received?

Feedback was received through phone and face-to-face interviews and email exchanges and was then shared with the producers of the climate information. This feedback process allowed for improvements in presentation of weekly and monthly climate updates and increased awareness of how and to what extent climate information could be used in decision-making processes.

Post mortem meeting and on-going activities

A 1997-98 El Niño postmortem meeting for the California Pilot Project was held in July 1998. It provided an opportunity for both the users and producers of climate information to share their experiences during the El Niño event and to identify ways to improve the preparation for and response to the impacts of climate variability. Another purpose of this meeting was to explore the potential for future collaborative activities to research the use of climate information within certain sectors and the institutional capacity for using this information.

At the postmortem meeting, participants indicated that they were interested in continuing to use climate information in their decision making. They offered several suggestions on how to improve presentation of the information. For example, it was noted that officials at different levels of management require different levels of detail regarding the climate information. Mid-management is interested in a short written summary of 6-10 day precipitation and temperature forecasts, while officials in field operations are interested in receiving graphics to further explain the written summary. Several participants requested that 6-month forecasts be made available a few months prior to the time at which budgetary decisions are made for the next fiscal year.

Based on the points listed above and other discussions at the postmortem meeting, participants agreed to consider the following suggestions as a continuation of the California Pilot Project:

- A La Niña project that would include the distribution of climate information during September-April 1998-99 in anticipation of La Niña's impacts on California and monthly documentation of how decision makers use climate information;
- Research projects in which institutions within a climate-sensitive sector work with producers of climate information to develop sector-specific forecast products;

- Research projects on the institutional structure and decision-making processes of climate-sensitive organizations;
- A breakfast meeting of media professionals and climate scientists to discuss how to best present climate information to the public;
- A breakfast meeting for CEO's of climate-sensitive organizations and climate scientists to discuss the potential for use of climate information within these organizations; and
- A project to coordinate the many Web sites that provide climate information for the state of California.

The NOAA - OGP El Niño - Southern Oscillation Web Site³⁶

In July of 1997, El Niño information available to the public was very limited. Most information from NOAA and other sources was made available to individuals in the scientific, climate, and weather forecasting communities either slowly through scientific publications or at a moderate rate through special climate-summary documents. Some information was available via the Internet / World Wide Web, but most of this was designed for scientific users. These sites included scattered predictions and analyses, diagnostics, and ocean and atmospheric observation. Of these sites, the one at the NOAA Pacific Marine Environmental Laboratory (PMEL) was the most advanced and contained introductory information on ENSO and Pacific Ocean observations in addition to near real-time ocean observations from the Pacific that were presented in a manner largely of value to scientific users.

The NOAA-OGP El Niño-Southern Oscillation Web Site was developed to provide the latest information on the 1997-98 ENSO event to a wide range of users on an ongoing basis. It was designed to provide easy access to the latest observations and forecasts and present them in a way that was understandable to the public, media, decision makers, and scientific users alike. The data were produced and updated by government and academic sources around the world. The approach was three-fold:

- First, set up the site with the latest and most often-sought information on a single Home Page. This page contains minimal text and is rich with graphics including the latest observations, forecasts, and analyses of the ongoing ENSO event. All of these were directly linked to the original information sources at NCEP, NOAA-CDC, PMEL, IRI, and others and automatically update as new versions are posted by the information sources.
- Second, the graphics first were linked to pages that explained the information in common terms.

- Finally, additional pages provided details and added links so that viewers could pursue more information at the level where they were comfortable.

Beyond providing the latest updates, the site served as a place to educate the user on what El Niño, La Niña and the Southern Oscillation are, how they are related, and what this means to them. The information provided through the Web site contained much of what was made available to the IRI Core Group members through the ENSO Rapid Response Project (described elsewhere in this document).

Responses to the pages were immediate and complementary. The number of users of the site doubled approximately every two weeks until the site peaked at over 2000 users each day in late 1997. Since the site was established, tens of thousands of users have accessed the site from over 100 countries. As the 1997-98 El Niño and its impacts drew greater attention, the site was documented and advertised in numerous media venues including several local, national, and cable news shows; newspapers (including the Wall Street Journal); and magazines (including Time, U.S. News, and Science). Additionally, links to the site were placed on numerous electronic publications and other Web sites.

Because of the nature of this mode of providing information, it is impossible to know how the data was used and who used it. However, one indication is the feedback provided by users from around the world. Many responses contained useful suggestions and questions about the data in the site. Whenever possible, these received individual replies and were used to improve the site. Many were queries from decision makers and the public, wanting more information. When the information was available online, they were pointed to these sources, or were sent additional information or put in touch with the appropriate experts. Particular examples of these include:

³⁶ The address for the NOAA-OGP El Niño-Southern Oscillation Web site is <<http://www.ogp.noaa.gov/enso>>.

- A Malaysian water resource engineer trying to understand past stream flow and its relationship to El Niño;
- Latin American farmers (rubber and coffee in Guatemala and El Salvador; shrimp in Ecuador; and general agriculture in Costa Rica, Panama and Bolivia) looking for forecasts on climate that might influence their crops;
- The German State Institute for Education wishing to use the web site to instruct teachers on the use of the Internet;
- Areal estate investment supervisor tracking El Niño and related weather forecasts to inform his property managers in twelve states;
- A securities/equities analyst looking for information on the relationship between El Niño and fish and shrimp yields in Indonesia;
- A fish-meal and fish-oil brokerage in Chile seeking ocean temperature forecasts to predict fish yields;
- A group of Belgian doctors concerned about potential health effects of El Niño during a planned mission to Colombia;
- A California ski resort looking to determine the impact El Niño might have on its upcoming season;
- A manager of an eco-tourism company in Ecuador seeking information on the potential of further mud slides;
- Mountain climbers looking to understand how El Niño might influence the safety of their expeditions to sites in Argentina and Peru;

- A scientist from the Smithsonian Institute looking for forecasts and data to understand changes in the timing of migrations of birds in tropical Latin America;
- Tourists looking for climate impacts on everything from diving to skiing, wind surfing and sailing, cruise ships, eclipse-viewing; and
- Brides-to-be worried about weather on their wedding days and honeymoons.

Finally, many teachers and students of all ages were directed to various Web sites and information resources to find answers to their questions that arose in graduate schools, universities, high schools, and elementary schools.

The NOAA-OGP ENSO site would not have been possible without the work of climate researchers at a number of organizations, both within NOAA and from the academic community. In particular, the site benefited from information provided through NCEP, IRI, PMEL, and the NOAA Applied Research Centers. OGP requested a wide range of information from them which improved the OGP-ENSO site. At the same time, those same organizations improved their sites, providing more and better climate information. Improvements in many of their sites allowed OGP to cut back on much of the job it had done to “interpret” scientific information that others provided. Both the climate information and its presentation improved dramatically as the event unfolded and more and more requests for information came from the press, general users, and decision makers. The result was an explosion of valuable information that is now available about El Niño, La Niña, the Southern Oscillation, and climate in general.

Regional Assessments of Climate Variability, Social Vulnerability, and Public Policy Program

The motivation behind NOAA-OGP's investment in a regional assessments effort is continual improvement in our understanding of how global-scale climate variations manifest themselves regionally and how the dynamics of decision making in climate sensitive sectors could be affected by the introduction of new analytical and predictive information. Equally interesting is the manner in which production and dissemination of climate information is influenced by the reactions of "users." The research objective is focused on both the process of assessment as well as on the products. That is, we believe this to be a long-term endeavor with eventual implications for both science planning and for regional institution-building. Central to each project in this early stage is stakeholder involvement, research teams resident in the region, and a research design that looks at climate variations across the range of timescales.

Pacific Northwest and Southwest

Since 1995, a multidisciplinary team of researchers at the University of Washington has been undertaking an integrated assessment of the interaction between climate and society for the purpose of identifying feasible adjustment measures for the Pacific Northwest (PNW) using the evolving technology of regionally refined global-scale climate forecasts. The following are the component studies of this regional assessment:

- The instrumental record of climate variability in the PNW;
- Impacts of climate variability on water resource use, including agricultural production, dams, transportation, recreation and Hanford operations in the Columbia River Basin;
- Evaluating policy/management systems for water resources;
- Determining sensitivity and vulnerability of salmon, sturgeon, municipal water supply, and waste disposal practices to climate change;

- Relationship between Columbia River annual flow and El Niño Southern Oscillation;
- Relationship between the ENSO and the Pacific Decadal Oscillation and PNW regional temperatures, precipitation, snow-pack, and stream flow;
- Incorporating climate information into reservoir operation;
- Impacts of climate variability on forests;
- History of impacts of climate variability over the past century on marine ecosystems; and
- Impacts of climate variability on coastal activities.

In January 1998, a regional assessment pilot activity centered at the University of Arizona was launched. This particular assessment was proposed by a group of investigators nationally recognized in interdisciplinary studies. This team hosted the United States Global Change Research Program Office of Science and Technology Policy (USGCRP-OSTP) Regional Workshop on Climate Impacts and through that process had already launched a dialogue with stakeholders in the region focused on the use of scientific research for decision making in climate-sensitive sectors. The project begins with analysis of stakeholder needs in the region and seeks to provide a sound basis for an assessment of climate impacts and response options. The research team will analyze the state of climate and hydrologic forecasting for the Southwest including analysis of quantitative precipitation forecasts, ensemble weather predictions, 30-90-day temperature and precipitation Outlooks, seasonal precipitation and water supply forecasts, and peak-flow, snowmelt-runoff forecasts. The team will conduct an early workshop to ensure that key personnel from agencies within the region are included to help identify physical science-based needs for improved climate information products. Social scientists within the team will conduct in-depth analyses of vulnerability to climate variations experienced by ranchers and urban water users.

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A multidisciplinary team of investigators from a consortium of Florida Universities have been focused on the development of methodologies to assess possible impacts of climate variability for agriculture and identify improved management of agricultural systems for given climate forecasts. In their second year of funding they began studies to characterize the historical influence of ENSO on crop production to identify areas and crops

most likely to benefit from application of ENSO-based climate forecasts. Analysis of winter precipitation in Florida has revealed important spatial patterns of ENSO influence, and differences in response to strong versus weak events. As they enter into their third year, this group will expand their regional analysis of the impacts of climate and increase substantially their interaction with regional stakeholders and determine how best to develop a climate service for the region.

Economics and Human Dimensions of Climate Fluctuations

In the early 1990s, NOAA-OGP introduced a social science-based research element with the goal of providing a more comprehensive understanding of how humans interact with the climate system, including both human drivers of change and human responses to climate variability and change. With the advancement in climate forecasting capabilities based on the prediction of the ENSO phenomena and the need to more fully understand societal adjustment to short-term variations in climate, the program is currently focusing its efforts on analyses of how society could potentially make use of new forecasting technology and how socioeconomic factors impede or encourage its adoption. To achieve this goal, the program is aimed at bringing social science research methodologies to bear on the application of forecast information to short-term adjustment issues, fostering new connections between social, physical, and natural science research, and identifying through research projects the needs of decision makers in climate-sensitive sectors. In particular, the Economics and Human Dimensions of Climate Fluctuations Program sponsors university- and government laboratory-based research projects to address the following questions:

- How does society currently adjust to climatic variability?
- Where will climate forecasts have the highest payoff for human welfare (which may not correspond to area of highest forecast skill)?
- What are the economic, institutional, and cultural factors that influence how decisions are made in the face of climate variability, and how do these factors constrain the use of forecasts?
- What are the distributional effects of the adoption of the forecasts (who gains and who loses)?

- What can we learn from the way in which scientific information flows from government entities to the public to ensure adequate dissemination of forecast information?
- What are the risks involved in issuing and acting upon false-positive or false-negative forecasts?
- What is the value of the forecasts to a specific sector or industry?
- How should forecasts be presented, and which variables are most significant, to ensure highest value to society?

Because NOAA-OGP has been investing for the past several years in research on the societal implications of climate forecasts, research provided some foundation for the application of forecast information during the 1997-98 El Niño event. For instance, the potential economic value of ENSO-based forecasts to the United States agricultural sector as a whole has been shown to be substantial (Texas A&M project, Yale University project).³⁷ Research has also demonstrated that the agricultural impacts of climate and the value of forecasts differ across regions, thus highlighting the importance of the distributional effects of climate variability and the need to more fully understand these effects. Moreover, the strength of an El Niño event and how the event is classified (e.g., the classification of the Southern Oscillation Index³⁸) appears to be more important than just knowing if an event is occurring (Texas A&M project).

Because of ongoing projects, researchers were able to take advantage of their planned field work to monitor individual, institutional, and governmental response to this El Niño event and determine whether and how forecast information was used or why, in certain contexts, it is not being used. Human-dimensions researchers also provided

³⁷ Current projects are listed in the following table, completed projects are not included in this listing.

³⁸ The Southern Oscillation Index (SOI) is calculated based on the differences in air pressure anomaly between Tahiti and Darwin, Australia. Negative SOI values generally correspond to El Niño episodes, while positive SOI values coincide with La Niña episodes. In general, the larger the SOI (positive or negative), the larger the ENSO event.

insight from their field work and analysis at several of the Climate Outlook Fora in Africa and Latin America this past year.

Although field work and analysis is continuing into the fall and winter of 1998 to gather data on the responses to the latest El Niño, some preliminary findings are illuminating both the needs of society as well as the current impediments to the use of these forecasts. For instance, through survey approaches, researchers are finding the following issues and variables to be important to certain users of climate information: total seasonal rainfall, increased spatial and temporal forecast resolution, consensus-based forecasts, forecast updates throughout the rainy season, adding national boundaries to forecast maps, presenting in Geographical Information System format, and translation into native languages (Tufts/University of Georgia project).

Survey research in developing countries is beginning to illuminate the significant impediments to the use of forecasts at the local level. While the 1997-98 El Niño event caused the worst drought in decades in parts of Latin America and Africa, small-scale farmers, especially those without irrigation, were unable to alter their practices based on forecast information because of resource and technology constraints and limited availability of land. In addition to lacking the means to benefit from the forecasts, farmers are often skeptical of the forecasts and are more likely to rely on their own methods of coping with climate variability. Planning for relief aid to local communities, however, is a promising area for the application of climate forecasts (Tufts/University of Georgia project and University of Arizona project).

Current Human Dimensions Program Research Projects

PROJECT TITLE	INSTITUTION(S)
An Integrated Assessment of the Social and Economic Effects of Extreme Climatic Fluctuations on Forests in the Northeast United States	Rand, NCAR, United States Forest Service, (USFS) Resources For the Future
Responses to Climate Variability and Utility of Climate Forecast Information for the Livestock Sector in the Arid & Semi-Arid Zone, South Africa	Colorado State University, University Witwatersrand
Social & Policy Implications of Seasonal Forecasting: A Case Study of Ceara, Northeast Brazil	University Of Arizona
Climate Variations and the International Management of the North American Pacific Salmon Fishery: A Game Theoretic Perspective	NCAR, University Montana
Effects of Seasonal Climate Forecasts on the Competitiveness in the Grain Market	Texas A&M University
The Use of Probabilistic Climate Forecasting Information in Water Resource Decision Making	Battelle PNNL, Oregon State University, George Mason University
A Case Study of Burkina Faso; Opportunities and Constraints to Using Seasonal Precipitation Forecasting to Improve Rainfed Food Production Systems at the Village Level in the Sahel-Sudano Region	Tufts University, University of Georgia
Climate Prediction, Information & Policy Response: A Retrospective Assessment of Drought Management in Oklahoma	University of Oklahoma
Human Health and Economic Dimensions of Climate Fluctuations	Harvard
Improvements to Water Resources Management Due to Climate Forecasts	Hydrologic Research Center
Early Warning of ENSO Events for Regional Agriculture	Battelle PNNL
Optimal Use of the Climate Prediction Center's Long-Lead Outlooks: Improved Interpretability and Decision-Analytic Case Studies	Cornell University
Improved Climate Forecasts and Pacific Rim Grain Supply and Markets	University California-Davis

Pacific ENSO Applications Center (PEAC)

The PEAC is a pilot-project that was established to conduct climate research, produce forecast information products, and perform outreach and education activities in response to ENSO-related climate variability in the U.S.-affiliated Pacific Islands (USAPI). These include American Flag jurisdictions and Freely Associated States (former U.S. Trust Territory) of the tropical Pacific.³⁹ Unlike other pilot activities in the South Pacific region, the PEAC is unique in that it was designed to be a centralized source for climate forecast information and regional application activities. The PEAC organizational structure includes institutions with unique functions and capabilities in the USAPI that are capable of providing a regional climate research, prediction, and information system. Such a mix was determined to ideally involve organizations with regional experience in academic research, operational responsibilities and expertise in forecasting activities, and access to local government agencies and industries involved in climate-sensitive sectors. With initial support from NOAA-OGP, other institutions forming the core of the PEAC organization include:

- The NOAA National Weather Service - Pacific Region (NWS-PR);
- The University of Hawaii - Joint Institute for Marine and Atmospheric Research (JIMAR),
- The University of Guam - Water and Energy Research Institute (UOG-WERI); and
- The Pacific Basin Development Council (PBDC), a regional organization directed by the Governors of the American Flag jurisdictions with close cooperative ties to the Freely Associated States.

Key areas of research, information product development, and education/outreach activities were designed to address the needs of climate-sensitive sectors such as water resource and coastal zone

management, fisheries, agriculture, civil defense, energy, health, and other sectors of economic and environmental importance to USAPI communities.

Because of its significant organizational linkages, experience, and reputation built in the region over previous years, the PEAC was well positioned to provide policy makers with useful forecast information in advance of and throughout the 1997-98 El Niño event. This information afforded regional, national, and local decision makers an opportunity to take early steps to reduce the impact of anticipated drought conditions. During 1997-98, for example, the PEAC continued to publish the "Pacific ENSO Update", a quarterly bulletin begun in 1995 to supply climate forecast information for the benefit of those involved in climate-sensitive sectors in the various jurisdictions of the USAPI.⁴⁰

To explain the predictive information and to help bolster preparations in the Pacific Islands for the 1997-98 El Niño, the PEAC held a series of multi-sector workshops on ENSO and briefings for government and industry officials involved in site-specific, climate-sensitive sectors. These activities were an extremely effective technique for identifying potential users and applications of climate information in the various island communities. Site visits to brief Ministers and Heads of State in Guam, Palau, Micronesia, Marshall Islands, Samoa, and Commonwealth of the Northern Mariana Islands helped establish a capacity for more effective use of information on El Niño and climate predictions relevant to the region. Participation by the PEAC in meetings of regional organizations from the tropical Pacific expanded the community of interest in applications activities while the El Niño event was in progress.

In lieu of formal Climate Outlook Fora, initial distribution of forecast information on climate variability related to El Niño was first made through the Pacific ENSO Update in March 1997 to Hawaii,

³⁹ Members of the USAPI include Hawaii, the Territory of Guam, the Territory of American Samoa, the Commonwealth of Northern Mariana Islands (CMNI), the Federated States of Micronesia (FSM), the Republic of the Marshall Islands, and the Republic of Palau.

⁴⁰ PEAC Web site and "Pacific ENSO Update": <<http://naulu.soest.hawaii.edu/Enso/index.html>

American Samoa, Guam, CNMI, Micronesia, Palau, and the Marshall Islands, with continued updates in subsequent issues. Project staff in Guam and Hawaii subsequently followed-up with a round of site visits to all the Freely Associated States and the U.S. Territories in the region between September 1997 and January 1998. Nearly every island jurisdiction established local government task forces to cope with serious drought — the primary consequence anticipated as a result of the event. On a community level, efforts of those groups have made a difference, by communicating that the drought was not a “fluke” that could end at any time, but rather a part of a much wider-scale phenomena that is highly predictable in the region.

Task force efforts resulted in mitigation measures that alleviated, within the capacity of local government resources and external assistance, the seriousness of the drought and its impact on the islands. An assortment of information on impacts and local government responses (along with those in neighboring island countries of the Pacific islands region) is available in the local island news section of the PEAC Web site or by contacting project personnel directly.

PEAC project work remains a highly valued resource within the tropical Pacific islands region and has contributed to anticipation of a more fully developed global network of similar activities. It is anticipated that NOAA’s National Weather Service

(NWS) will assume full responsibility for financially supporting the PEAC in the near future, transitioning the PEAC from a research-based pilot activity to fully operations-oriented center. In the meantime, the PEAC is actively engaged in further development of operational activities, research, and applications projects.

Specific PEAC Response Activities during 1997-98:

- Pacific ENSO Update alert of El Niño conditions (March 1997) and continuing publication of the “Pacific ENSO Update”
- Development of quantitative rainfall forecasts beginning in September 1997
- Consultation with the U.S. Department of Defense regarding potential relief efforts from El Niño related impacts
- Consultation with Federal Emergency Management Agency regarding fast-tracking existing projects to secure and enhance potable water supply for the islands
- Ongoing support for national task forces coordinating regional activities and adaptation of applications strategies to the community level, including weekly teleconferences
- Participation in the South Pacific Regional Environment Program Conference on Climate Change in the Pacific (August 1997)

Applied Research Centers

The Applied Research Centers (ARCs) supported through NOAA-OGP are a group of university- and government-based research centers and cooperative programs designed to further understand the climate system and its predictability from seasonal to decadal and from regional to global scales. This effort is supported under the Climate Dynamics and Experimental Prediction (CDEP) program. The ARCs are involved in a variety of activities, including:

- general climate system research and modelling;
- analyses of historical climate records and the current atmospheric state;
- development of climate diagnostic techniques; and
- development of carbon system models.

Of the group of ARCs, four are involved in the transfer of research results into information that can be directly used by society to plan for the effects of climate variability. These include the NOAA Climate Diagnostics Center (NOAA-CDC), the Scripps Institution of Oceanography Experimental Climate Prediction Center (SIO-ECPC), the Center for Ocean-Land-Atmosphere Studies (COLA), and the Florida State University Center for Ocean-Atmosphere Prediction Studies (FSU-COAPS). During the 1997-98 El Niño, each of the centers were involved in providing observational and forecast information to user groups through the variety of techniques summarized below.⁴¹

Each ARC has a Web page which was designed to communicate information about the El Niño event, each including general ENSO information and descriptions, and in some cases, forecast products. All of the sites received thousands to tens of thousands of hits per month during the event (the CDC received in excess of one million hits per month at the event's peak). Many of the Web site visits led to email questions that were either answered directly or forwarded to other Web sites or

organizations. Also available on the ARC sites were tropical Pacific SST forecasts generated by the ECPC and COLA, and COLA forecasts of North American temperature and precipitation anomalies.

Press conferences and media interviews were given by ARC representatives on a wide range of topics associated with ENSO, including its character, predictability, and ramifications for related climate variability impacts such as fire, in subsequent seasons. Specifically, some of the interactions with the news media included:

- Interviews for national and international press, Inside Science (a video science magazine), and the television program Techno-Politics (COLA)
- In September and October 1997, CDC sponsored a series of press conferences to brief news media and government representatives on the likely impacts of the developing El Niño on U.S. climate (local, regional, national, and international press)
- The SIO-ECPC created a video of the evolving El Niño that was distributed to major media outlets (national and international press, The Learning Channel, the Scripps Institution of Oceanography video magazine, and numerous local stations in cities throughout the U.S.)

A number of presentations were given by ARC representatives at various ENSO meetings and symposia and to government organizations before and during the event. For example, CDC scientists gave a presentation to the heads of Caribbean meteorological organizations on the climate risks from El Niño in the Caribbean; and a presentation entitled "El Niño: Fact or Fiction?" to an audience of TV weather broadcasters at the Ninth Annual Steamboat Weather Summit, in Colorado.

Directed interaction between climate scientists and users of forecast and observational information was organized and sponsored through the CDC.

⁴¹ This summary is intended to give a flavor of the activities that occurred; further information can be obtained by consulting the NOAA-OGP Website <<http://www.ogp.noaa.gov/mpe/CDEP/cdep.html>> or by directly contacting the ARC Websites: NOAA-CDC <<http://www.cdc.noaa.gov/ENSO/>>, SIO-ECPC <<http://meteora.ucsd.edu/ecpc/>>, COLA <<http://grads.iges.org/cola.html>>, and FSU-COAPS <<http://www.coaps.fsu.edu/>>.

Information provided through a workshop for western water managers on the likely effects of El Niño on the timing and magnitude of the spring runoff helped the Bureau of Reclamation adjust the management plan for Glenn Canyon dam to account for unusual climatic conditions. The workshop was attended by representatives from the Bureau of Reclamation, Corps of Engineers, National Park Service, National Weather Service, and various state water managers. The CDC has also 1) worked with sugar producers and governments in the Caribbean to help them better understand the historical impact of El Niño on sugar production and to make better use of climate forecasts to plan sugar plantings, and 2) interacted with water resources scientists from Tanzania, briefing them on NOAA research related

to water-management activities, and emphasizing monitoring and predictions on the seasonal-to-inter-annual time scales, including the impact of ENSO on their regions.

In general, the activities of the ARCs indicated a strong interest amongst decision makers, the media, and the general public in forecasts of El Niño. Experience generated through the latest event is a first step in sensitizing these groups to advances in climate forecasting and observational systems, and in learning what information is most useful to decision makers regarding climate variability. The ARC activities were fundamental to raising public awareness of ENSO and therefore facilitate future communication and dissemination of climate information.